Experimental and numerical study of cw green laser crystallization of a-Si:H thin films

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Crystallization and grain growth technique of thin film silicon are among the most promising methods for improving efficiency and lowering cost of solar cells. A major advantage of laser crystallization and annealing over conventional heating methods is its ability to limit rapid heating and cooling to thin surface layers[1-3].

Laser energy is used to heat the amorphous silicon thin film, melting it and changing the microstructure to polycrystalline silicon (poly-Si) as it cools. Depending on the laser density, the vaporization temperature can be reached at the center of the irradiated area. In these cases ablation effects are expected and the annealing process becomes ineffective.

The heating process in the a-Si thin film is governed by the general heat transfer equation [4-5]. The two dimensional non-linear heat transfer equation with a moving heat source is solve numerically using the finite element method (FEM), particularly COMSOL Multiphysics [6]. The numerical model help to establish the density and the process speed range needed to assure the melting and crystallization without damage or ablation of the silicon surface.

The samples of a-Si obtained by physical vapour deposition were irradiated with a cw-green laser source (Millennia Prime from Newport-Spectra) that delivers up to 15 W of average power.

The morphology of the irradiated area was characterized by confocal laser scanning microscopy (Leica DCM3D) and Scanning Electron Microscopy (SEM Hitachi 3000N). The structural properties were studied by micro-Raman spectroscopy (Renishaw, inVia Raman microscope) [7].

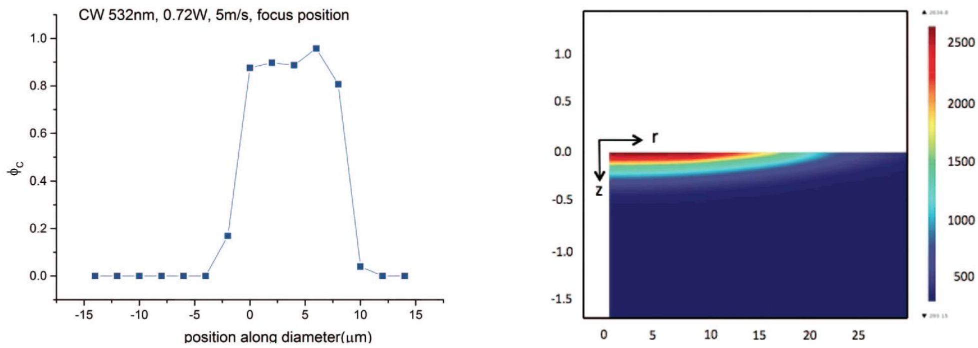

Fig. 1 a) Experimental crystalline fraction (Φ_C) profile measured on the surface of the sample along a perpendicular line to the laser processed track. b) Numerical temperature profile at a cross section of the sample perpendicular to the laser processed track.

The process parameters predicted by the numerical model are consistent with those experimentally observed.

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